International Conference on Case Histories in Geotechnical Engineering
(2008) - Sixth International Conference on Case Histories in Geotechnical Engineering

14 Aug 2008, 7:00 pm - 8:30 pm

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6th International Conference on
Case Histories in Geotechnical Engineering, Arlington, VA, August 11-16, 2008

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ABSTRACT

This paper discusses the design, construction, and performance of the support of excavation system used at 300 New Jersey Avenue jobsite. The temporary support of excavation system is more complicated than the typical urban site in Washington D.C. and had to be adaptable to many different and variable conditions surrounding the site. These conditions included support of a six and seven story office building, WMATA's Red Line Subway tunnel under D Street and the support of the 24 foot wide brick and stone Tiber Creek Sewer, which was built in the late 1800's to drain a major portion of Washington, DC.

The depth of the excavation is 60 feet and the top 30 feet is a mix of Miocene Age Terrace deposits of sand, gravel, silt, and clay. The bottom 30 feet is hard Cretaceous clay. The groundwater at the interface at the top of the clay was a concern due to the possibility of washing away the upper soils during installation of typical soldier beams and wood lagging. Therefore, we chose to use slurry wall clamming techniques to install Piles in Self Hardening Grout (PSHG) on two sides of the site and tangent/bracket piles on the side adjacent to the existing buildings. The bracing included tiebacks, corner braces, wales, rakers, and cross lot struts. In addition Pin Piles with support steel were installed to hold the existing utilities under First Street and a suspended platform over the excavation, for the excavator's long stick backhoe.

PROJECT LOCATION AND SCOPE

51 Louisiana Avenue is located at 300 New Jersey Avenue N.W. Washington D.C. across from the U.S. Capitol. The Site is bounded by First Street N.W. on the west, New Jersey Avenue N.W. on the east, D Street N.W. on the north and a seven and six story office building for the Jones Day Law Firm to the south (The Acacia Building). Underneath D Street runs WMATA's Red Line subway tunnel and to the south of the site runs the 24ft wide Tiber Creek sewer. The project will combine the new building with the existing Acacia buildings by a glass and steel nine story atrium. The site was previously occupied by a four story parking garage which was supported on steel bearing piles. Clark Foundations, LLC scope of work included support of excavation for the new six story below grade parking garage, bracket pile underpinning for the adjacent building, site dewatering, utility support for two telephone lines and two electric conduits, a suspended platform for the excavator's long stick backhoe and a two story office trailer support platform.

Clark Foundations designed and installed the above scoped work used on the project. The excavation support system consisted of a Pile in Self Harden grout wall (PSHG), a tangent wall with brackets, utilization of existing WMATA soldier beams with new lagging, and a series of pin piles and support steel to hold the existing utilities and the excavator's long stick backhoe platform. The vertical elements were supported by using both interior and exterior bracing. Interior bracing included cross lot struts, rakers, and corner braces. The exterior bracing consisted of high capacity drilled tiebacks.

The following companies comprised the construction team that excavated 300 New Jersey Avenue: Clark Foundations, LLC, Bethesda MD; Clark Construction Group Inc., Bethesda MD; Wrecking Corporation of America, Alexandria VA. The respective owner and design team are JBG Companies, Chevy Chase MD; HKS Architects, Dallas TX; and SK&A Engineers, Washington D.C.

GEOLOGY

Borings reveal the top 7 to 20 feet below the existing ground to be fill material due to previous development at the site. The fill was composed mainly of low plasticity silt and clay mixed with fine to medium sand traces of crushed concrete debris, and brick and asphalt fragments. Below the fill for a depth of 14 to 43 feet were lean clay, sandy lean clay, sand, and gravels from the Miocene Age. Beneath these soils were Cretaceous Age Potomac Group soils, which consisted of gravel, sand, silt and very hard clay. Groundwater in the area was found to be 22 to 24 feet below existing site grades or at elevation 0.00 feet on top of the impermeable clay layers.

PRECONSTRUCTION AND PRELIMINARY SITE INVESTIGATION

Months before the beginning of construction an extensive amount of research and site investigations were performed to determine the existing conditions and location of the adjacent structures and underground utilities.

The project was complicated by the existing parking garage on the site that had to be demolished. This structure had two below grade levels. Its foundation system typically was large spread footings. However along the north perimeter two rows of columns were supported on bearing piles. The piles were necessary to carry the building column loads to below the adjacent WMATA tunnel. These piles would later impact the excavation of the raker berms.

Adjacent to the north side of the site runs the section of the WMATA Red Line Tunnel from Union Station to Judiciary Square. WMATA drawings indicated this section of the tunnel was constructed by a cut and cover method using soldier beams and wood lagging for its excavation support. From the drawings the location and depths of the existing shoring piles were plotted in relation to the new building perimeter. The toe elevation of the soldier beams were assumed to be 10ft below the bottom elevation of the tunnel. It was determined that these existing pile could be used as part of the new support of excavation system. Test pitting for these beams were performed in several areas to confirm their location as well as well as the soldier beam section size that was used, to aid in the design of the new support of excavation.

Structural drawings for the Acacia building to the south of the jobsite revealed that the existing spread footings encroached into the new construction. In order to be able to install the tangent wall without interfering with new building foot print the existing perimeter footings needed to be saw cut back to 9" passed the outside face of the existing wall. After analyzing the situation it was determined, in conjunction with the structural engineer (SK&A), that the existing footings could be trimmed due to the additional support provided by the brackets from the tangent piles. It was also discovered that the bottom elevation of these footing varied substantially causing us to rethink our tangent wall drilling sequence to prevent undermining and possible settlement of the existing building.

Many test pits to find existing utilities were dug prior to the start of construction. Along the west side of the jobsite two electric and telephone lines were uncovered to determine their location and the type of support system required to suspend these lines over the excavation. Further test pits were also required along the south side of the site, at the existing building courtyard, to determine the location and quantity of the existing building utilities that needed to be supported as well.

Along the east side is the existing Tiber Creek sewer. The 24 ft wide by 14 ft deep sewer originally drained the northern areas of Washington D.C. and ran across the Mall into the Anacostia River. It was channeled and covered in the late 1800's using stone and brick. Since its exact location was unknown at the start of the project and to assist in the WASA review and approval process two test pits were cut through the east wall of the existing parking garage. After digging the test pits and exposing the sides of the sewer the location of the PSHG wall and the shape of the project had to be revised accordingly. The new foundation wall was moved westward approximately 2.5ft and the shape of the parking garage ramps was revised to reflect the actual location.

SITE LOGISTICS

Since the jobsite is located in the heart of D.C. (just blocks away from the Capitol Building) combined with the irregular and small shape of the site made the everyday site logistics very difficult and challenging. During the ground to grade phase of the job, trailers for the architect, the general contractor, the excavator, and Clark Foundations were required on site. Due to the limited real-estate available a double story trailer platform was designed and built by Clark Foundations along D Street. Since the north wall WMATA soldier beams, along D Street, needed a six foot slope cut at the top one side of the trailer platform had to be supported from the existing metro piles while the other side could bear on D Street (see fig. 1).

Fig. 1. Office Trailer Support Platform

Deliveries of the soldier beams, internal bracing steel, cement and other miscellaneous items had to be coordinated well in advance with the excavator so as not to get in the way of each others work. Due to the site limitations deliveries were required to be unloaded from First Street N.W., which necessitated two flagmen to temporary close off First Street while the shipments were unloaded (see fig. 2).

Fig. 2. Unloading of Raker Brace Steel Shipment

A 75 ton link belt service crane was required to remain on site to assist in the installation of the sheeting and shoring components. However, due to the space requirements around the perimeter of the job the service crane could not be situated outside the excavation. Having the service crane inside the excavation posed a unique set of conditions. Not only did our service crane have to maneuver around the excavator's equipment, that was constantly hauling dirt out of the hole, but half of the site was unavailable for any equipment to maneuver in as it was taken up by the first tier raker berm for a good portion of the excavation process (see fig. 3).

Fig. 3. Maneuvering of 75 Ton Link-Belt Service Crane

Another aspect of any downtown site is where the excavator's ramp is going to exit the site. The excavator alternated his ramp location from the east to west to the east again, in conjunction with our Piles in Self Harden Grout clamming operation. The final location of the ramp would be in the south east corner of the site. The site was too confined to allow a ramp to sub-grade therefore a long-stick backhoe was required to finish the excavation of the site. However, to complicate the matters further, due to the site logistics and space limitations this operation was only feasible to be performed from First Street side of the job. This posed a unique challenge as the backhoe long stick somehow had to get over the existing utilities that were suspended above the site by our pin pile frame support system. In order to overcome this situation a platform for the excavator's long stick backhoe was constructed overhanging the excavation.

In 1953, an addition to the Acacia building was being constructed. The original location of the Tiber Creek Sewer ran through the new construction. In order to allow the new construction to take place Tiber Creek was diverted to run in between the two buildings. The buildings spanned over Tiber Creek with a series of piers and concrete steel composite girder beams. However, we came to realize while installing the PSHG wall in this area that parts of the old Tiber Creek Sewer was never demolished and removed. This old portion of the sewer was in direct conflict with the new building structure. Due to the time constraints and the tight schedule to complete the job, it was not feasible to go back to D.C. WASA and obtain a new permit to demolish and remove the old sewer wall. Therefore a complete re-design of the new building, along the east wall and the courtyard area, as well as the support of excavation was implemented as the excavation continued. Since the excavation was well on the way a new sequencing of work needed to be put into action so as not delay the job. This required a great deal of coordination between Clark Foundations, the excavator, and the general contractor.

DESIGN PARAMETERS

Soil pressure

- Soil weight of 125 pounds per cubic foot was used.
- Hydrostatic pressure was added to the PSHG and Tangent Wall Design as it was not a free draining system.
- Friction angle of 32 degrees was used.
- Triangular earth pressure loading was used for stages 1 and 2 (one tier or less bracing).
- Trapezoidal earth pressure loading was used for stages 3 and 4 (two or more tiers of bracing).

Surcharges

- A construction and traffic surcharges of 600 pounds per square foot vertical was added to the design in areas where the surrounding streets were within a 30 degree failure plane from the bottom of the excavation.
- Building surcharges were calculated and added where building footings fell within a forty-five degree influence of the excavation.

CONSTRUCTION

East and West Side -Pile in Self Hardening Grout (PSHG)

Due to the tight schedule of the job, a plan was developed to mobilize the PSHG Wall operation along First Street, while the excavator finished demolishing the remainder of the old parking garage foundations along the east half of the job.

The Piles in Self Hardening Grout wall is a hybrid sheeting system combining slurry wall excavation operation with soldier beam and wood lagging. This is a temporary shoring support system that greatly reduces groundwater inflow.

In lieu of excavating a panel under slurry and displacing the slurry with tremie concrete and a reinforcing steel cage, the slurry is self hardening. The soldier beams and lagging are prefabricated as a panel and placed in the liquid slurry. Each panel once assembled weighed seven tons (see fig. 4). Conventional waterproofing is later applied to the face of the lagging, prior to construction of the building foundation wall.

Fig 4. Fabrication of PSHG Wall Panel

Mobilization and installation of the Pile in Self Hardening Grout System involved several operations:

- A cement silo for bulk storage and a 4 cubic yard blender were used to batch the self hardening grout. The slurry is a mixture of Type III cement and attapulgite clay.
- Two crawler cranes were mobilized. One crane was for the clamming operations using our free hanging clam buckets and another service crane was for the setting of the pre-fabricated soldier beams with lagging panels.
- The clamming buckets are free hanging cable operated buckets that are 30 inch wide.
- The soldier beams were pre-fabricated with reservations for the future tiebacks, and paired together with wood lagging to make a panel.
- Pre-excavating along the sheeting line was performed in order to remove any existing obstruction such as building foundations or utilities.
- A glory hole was established for spoils from the clamming operation.

Fig. 5. PSHG Wall Clamming Operation With Service Crane Holding Panel To Be Set.

In order to avoid communication of open excavated panels a sequence was planned to allow each “primary” panel to cure for seven days before the secondary panels were excavated. The secondary panels were installed in such a way that it bit 8” into the sides of the primary panels to ensure a water tight system. The size limitation of the site required us to move from the west side to the east side of the site many times and made sequencing of the panels very difficult.

West Side – Hanging Utilities

After completion of the PSHG Wall along First Street, we proceeded with excavation around and under the existing utilities. This required the use of small backhoes and plenty of handwork. As the utilities were exposed, a system of steel channels and hanger rods were installed across the top and bottom of the utilities and attached to a series of pin piles installed beforehand (see fig. 6).

Fig. 6. Installation of Utility Support Structure

Incorporated into the utility support was a 20ft long x 16ft wide platform for the excavator's long stick backhoe (see fig. 7). This platform was designed to overhang the excavation. Extra pin piles and steel beams were added to this area of the utility support to help reinforce the platform. Concrete mats that were 10ft long x 4ft wide x 12" thick were used for the decking of the platform.

Fig. 7. Excavator's Long Stick Backhoe Platform and Utility Support Structure

North Side – WMATA Shoring

Under D Street is WMATA's Red Line subway tunnel. This tunnel was constructed in the 1970's using conventional soldier beams, wood lagging, and cut and cover construction. The soldier beams location varied from 6ft outside the new building line to encroaching into the new basement. The shoring system utilized the existing soldier beams by installing new wood lagging, three tiers of steel rakers and concrete heel blocks as the excavation progressed (see fig. 8).

Along the north wall, the new building slab on grade parking level stepped up a floor from P6 level to P5 level. This step was incorporated in the new building design so it would not be situated in the influence line of the WMATA metro tunnel. In order not to undermine the new building footings and the WMATA Tunnel where this transition occurs a system of soil nails and shotcrete were used to retain the earth in this area. The height of the shotcrete wall ranged from 20 feet to 6 feet and incorporated a 4 foot x 4 foot staggered soil nail pattern. The soil nails consisted of 75 ksi number 7 bars with 6inch x 6inch x 0.75inch thick bearing plates and the shotcrete was 4inches thick reinforced with 4inch x 4inch square wire meshing (see fig. 8).

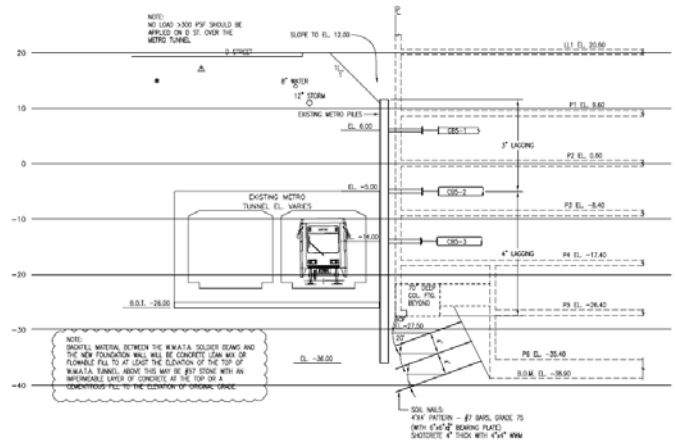

Fig. 8. Section at North Wall WMATA Piles

South Side – Tangent Pile Wall

Along the south side is the existing six and seven story Acacia Building. The foundation of this building was concentric spread footings. A tangent pile wall was determined to be the best design to limit deflection of the shoring system adjacent to the building and to prevent the loss of fine soils from behind the wall. The system consisted of 30 inch diameter holes drilled directly adjacent to each other. The first series of "primary" holes are drilled 4feet-9inches on center and drilled to a depth 10 feet below sub-grade. A wide flange beam is inserted in the hole and then the hole is tremie filled with 3500 psi concrete to a height of 4ft below the underside of the existing building's footing. A series of "secondary" holes are drilled tangent between the primary holes and set back 4 inches. These holes are drilled to a depth of 2 feet below sub-grade and tremie filled with 3500 psi concrete in the same manner as the "primary" holes (see fig. 9). The concrete of the "primary" and "secondary" holes were purposely kept low to aid in the installation of the steel support brackets. In order to prevent loss of material the remainder of the annular space was filled with a cement bentonite mixture that hardens to the same consistency as the soil it is replacing.

Fig. 9. Tangent Wall Drilling Operation

To limit the potential settlement of the "trimmed" footings, steel brackets were installed from the back of the tangent piles to the underside of the footings. These brackets were pre-loaded to 100 percent of the design load using hydraulic flat jacks. Once the bracket piles were installed and jacked the tops of the tangent pile wall and brackets were encased in 3500 psi concrete.

During the excavation operation the concrete face of the tangent piles were scabbled back to the face of the soldier beams to provide a flush face. Any imperfections were shotcrete filled. This face was later covered with conventional waterproofing (see fig. 10).

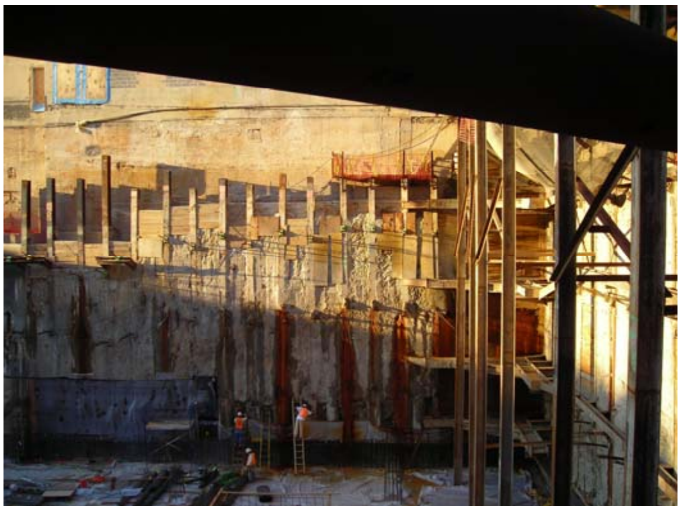

Fig. 10. Tangent Wall Scabbled Back to Face of Soldier Beams and Waterproofing Being Installed

Bracing System

The north side was braced with three tiers of steel wales, corner braces, and rakers with continuous 4 ft wide x 5 ft deep heel blocks per tier. Maintaining an earth berm against the WMATA tunnel was critical to limiting deflection of the existing soldier beams. Mass excavation had to be performed to sub-grade and the heel blocks excavated and concreted below sub-grade in a safe manner. After setting the steel corner braces and rakers, each brace was pre-loaded to 100 percent of the design load using hydraulic jacks (this was a WMATA requirement).

Along the east side and west side three to four tiers of tiebacks were drilled, grouted and tested to provide lateral stability. Tieback reservations had been prefabricated through the soldier beams in the PSHG wall before installation.

Due to the irregular shape of the south side a combination of steel cross-lot bracing with tiebacks were required. The Tiber Creek Sewer and the adjacent buildings needed a stiff system in order to limit deflection. Therefore a tangent pile wall was used. As with the PSHG wall the tieback reservation were prefabricated in the soldier beams before installation. Coordination of access for tieback drilling while working through the cross-lots had to be thoroughly planned to provide enough space and headroom for the tieback drill rig (see fig. 12).

Fig. 11. Internal Steel Raker, Corner Braces, and Cross-Lot Bracing

Fig. 12. Tieback Drill Rig Drilling Tiebacks Underneath Low Headroom Cross-Lots.

Dewatering

Dewatering deep wells were installed in the four corners of the site and on top of the WMATA tunnels, in an effort to control the water at the intersection of the different support systems. In order to accomplish this, seven deep wells were installed. Each well consisted of a drilled 12 inch diameter hole, 6 inch slotted pvc well screen, well sand backfill, and 1.5 horse power electric pump. The wells were drilled to a tip elevation between 15 feet to 30 feet below sub-grade. However, the wells located above the metro tunnel were drilled to a tip elevation 24 feet below surface grade to avoid interference with the metro tunnel. During the excavation portion of the job, each well produced 5 to 10 gallons per minute except the wells located above the metro tunnel which remained dry.

MONITORING

WMATA required an extensive monitoring system established before construction at the site was able to proceed. Pre-construction surveys, crack monitors, optical survey points, and baseline readings were established prior to the start of construction. Survey readings of the tunnel adjacent to the site were taken weekly. The survey readings of the tunnel farther away from the site were taken monthly. The readings were taken at 25 foot interval, at 5 points around the tunnel, to monitor horizontal and vertical movement. Vertical movement varied in the range of 0.00 inches to 0.20 inches depending on temperature. Horizontal movement indicated a few survey points moving 0.25 inches towards the excavation in the middle of the site, while the ends of the tunnel were held to 0.10 inches.

In addition to the monitoring required inside the WMATA tunnels, numerous reflective prisms were installed on the adjacent building walls and at the tops of the soldier beams. Readings for horizontal and vertical movement were taken and reviewed two to three times per week. The movement experienced by the Acacia building and the soldier beams adjacent to the building was less than 0.375 inch both vertically and horizontally.

Also, due to the sensitive nature of the Tiber Creek sewer and the Acacia Building five inclinometers were installed within the PSHG Wall in front of these structures. The inclinometers were read once a week. In addition, four load cells were placed on selected tiebacks along this same area. They were installed to measure the loads within the tiebacks, as the excavation progressed, and to monitor any creeping that may occur due to the high quantity of clay around the bond zone of the tiebacks.

CONCLUSION

The temporary support of excavation for 300 New Jersey Avenue was unique and challenging. The sheeting and shoring system performed very well and limited the movement of the critical surrounding structures. The Acacia building and the soldier pile adjacent to the building moved less than 0.375 inch both vertically and horizontally and the WMATA tunnel moved less than 0.25 inch vertically and horizontally.

The combination of the tangent wall, PSHG Wall and the seven deep wells created a sufficient bath tub that kept the jobsite dry during the excavation process.

The excavation team also performed very well in adapting to the difficult site conditions. When differing site conditions were encountered the team was able react to the situation and immediately come up with a solution to keep the excavation progressing without delays to the tight schedule. This was possible due to the cooperation and collaboration of the entire project team.

Throughout the 9 month duration of the support of excavation work, more than 44,000 man hours were worked in very difficult conditions, without one lost time injury.

REFERENCES

Schnaubel Engineering North, LLC [2005]. “Geotechnical Engineering Report – Office Building Development for 51 Louisiana Avenue, N.W. Washington D.C.”